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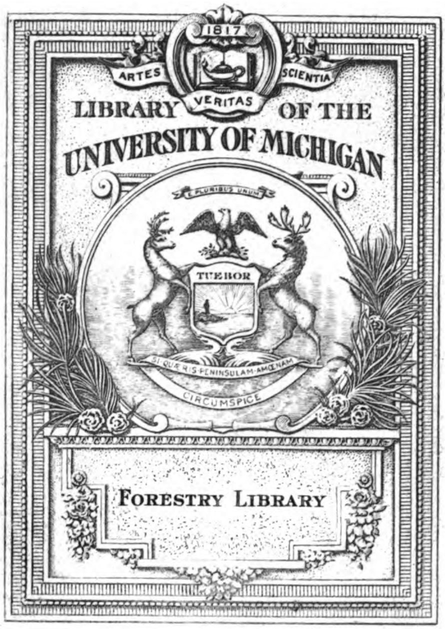
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COTTON PROBLEMS IN LOUISIANA.[1]

By **O. F. Cook**, *Bionomist in Charge of Crop Acclimatization and Adaptation Investigations.*

INTRODUCTION.

Louisiana must be considered as a State adapted to raising long-staple cotton. Short staples can also be grown, but there are special conditions that favor the production of long staples. The planting of early-maturing short-staple cottons in Louisiana was advised in the first years of the boll-weevil invasion as a means of avoiding acute distress from complete loss of crops, but this was because of the late-maturing habits of the long-staple varieties, which rendered them very susceptible to weevil injury. Earlier long-staple varieties are now available, and it is believed that these offer the best prospect of maintaining a permanent cotton industry in Louisiana.

Whether long-staple cotton can take the place of sugar cane on any of the Louisiana lands and how far such a substitution may be expected to go are questions of present interest, but even outside the sugar districts it is important to have more definite knowledge of the possibilities of improvement. The presence of the boll weevil introduces a new element of uncertainty and requires many readjustments that are not yet complete. New varieties and improved cultural methods have been developed in recent years by the Department of Agriculture and are likely to be useful in Louisiana, but they have still to be tested and adapted to the local conditions. There are problems of other kinds that remain to be solved. The selling of the cotton must be considered, as well as the raising of it. The substitution of short fiber is now a more serious menace to the long-staple industry than the boll weevil.

Some of the factors that affect the cotton industry are of a general nature and some are peculiar to Louisiana and adjacent districts. To meet special conditions special measures may be required, and some of these needs are already apparent. Thus, the need of community action is especially great in the Louisiana cotton industry, for reasons that are easy to see when the local conditions are considered. The moist climate and luxuriant growth of the plants increase the danger of weevil injury. Measures of protection, if they are to be at all effective, must be enforced by the concerted action of whole communities, and community agreements are also necessary in order to maintain the selection and preserve the purity of superior types of long-staple cotton. Finally, there is special need with long-staple cottons that commercial quantities of uniform high-grade fiber be produced in each community in order to market the crop to the best advantage. The individual farmer working alone is usually unable to secure more than a small part of the advantage that could be obtained if whole communities of farmers would unite in measures of improvement.[1]

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[1] Issued June 21, 1913.

INCREASING COST OF LABOR.

The higher prices that have ruled in the cotton market in recent years do not mean that there has been a corresponding increase in the profits of large farms or plantations. The cotton crop still has to be picked by hand. Hopes of cotton-picking machines are not yet realized. The scarcity and higher cost of farm labor in the South is one of the general factors of cotton production that has changed rapidly in the last few years. The cost of picking has almost doubled in five years in some parts of Texas, and many laborers have been attracted from Louisiana. The rapid increase of city and town populations in the South has also drawn heavily, and especially upon the more intelligent and efficient part of the laboring population of the farming districts, for the towns afford more regular employment as well as higher wages.

With some of the laboring population increased wages mean a still further decline in efficiency, because a living is assured by fewer days of work. Instead of working four or five days in a week they may " get along " by working only two or three days.

The breaking up of large estates for sale or rent to small farmers is another factor in reducing the supply of labor available for the large planter, for the small farmers can live from their own land and are no longer in the market as general laborers. It is useless for large landowners to plant cotton unless pickers can be had when the harvest season arrives. Miscalculations on this point occasion losses of millions of dollars every year.

Thus, we have in the labor conditions alone a reason why it is becoming more difficult to maintain cotton production by hired labor on a large scale, or the plantation system. The fact that the labor demands of the cotton crop are not distributed regularly through the season means that farming on the basis of cotton alone is uneconomic from the standpoint of labor supply, to say nothing of other disadvantages of a one-crop system. In other words, cotton culture is likely to be more profitable as a part of a system of mixed farming. But this tendency to decentralized production must carry with it a larger extent of community cooperation, for reasons already intimated.

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[1] Cook, O. F. Cotton improvement on a community basis. U. S. Department of Agriculture, Yearbook, 1911, p. 397–410, 1912.

DETERIORATION OF UPLAND LONG-STAPLE COTTON.

One of the chief objects to be gained through the organized cooperation of cotton growers is to improve and maintain the quality of the crop. Even before the arrival of the boll weevil in the long-staple districts the manufacturers had begun to complain of a serious decline in the quality of the cotton that was being produced in Louisiana and Mississippi. The complaints were on the grounds that the cotton was sent to market in worse condition and that the fiber was more uneven. It is easy to see that both of these results would follow naturally from changes that were taking place in the long-staple industry. Labor was becoming more careless because of less effective control, and the old system of separate plantation gins was being abandoned because of the greater expense in comparison with the modern power gins.

The result of bringing together at a public gin all the cotton of a neighborhood is that the varieties become mixed, so that uniform fiber is no longer produced. The superior stocks that were formerly maintained on some of the plantations became contaminated, and it became more and more difficult to secure supplies of good seed. The tendency of the old system had been to preserve the beneficial effects of selection, such as any careful planter might practice, and extend them over the community, because the crop of each plantation was handled separately and the seed that might be sold by such a planter would also be handled separately on other plantations. But the system of public gins has the opposite effect of making it very difficult to maintain stocks of pure seed. And yet supplies of pure seed are a fundamental necessity if a long-staple industry is to be maintained.

The commercial and industrial value of long-staple fiber depends very largely on uniformity, for lack of this quality greatly increases the cost of manufacture. The short fibers have to be sorted out by elaborate mechanical processes. If the buyer detects the presence of short cotton he will pay only short-cotton prices for the whole bale. Indeed, it is often difficult to dispose of mixed bales, even at short-cotton prices.

The problem of preserving the uniformity of superior varieties of cotton by continued selection as a means of securing large yields and maintaining the quality of the fiber has received special attention in recent years. Improved methods of selection, easier to apply and at the same time more effective, have been developed.[1]

Selection of seed should be considered as a regular part of the farm operations with cotton. Every farmer should either select his own seed or buy it from a more careful neighbor. Neglect of selection is responsible for an enormous annual loss to the American cotton industry. A hundred million dollars would be a small estimate of this factor of agricultural inefficiency.

BEHAVIOR OF THE COTTON PLANT UNDER LOUISIANA CONDITIONS.

No other part of the cotton belt has produced Upland long-staple cotton of such high quality as the lower Mississippi Valley, in the States of Louisiana and Mississippi. Though excellent long-staple cotton can be grown in other States it is still doubtful whether any could compete in the production of fiber of the highest quality if the Louisiana and Mississippi planters were to take full advantage of the favorable natural conditions. In order to secure fiber of the greatest length and strength it is necessary that the plants have an adequate and continuously available supply of moisture, and this is afforded by rich alluvial lands like those of the Delta region, which has long been famous as the center of long-staple production.

Though the rich soil and abundant moisture of Louisiana are factors that favor the production of long-staple cotton, they also have the disadvantage of inducing too great luxuriance of vegetative development. When cotton plants grow too rapidly in the earlier stages they produce larger numbers of vegetative branches, each of which has the same possibilities of development as the main stalk. The result is a large, bushy, slow-fruiting plant. The development of the fruiting branches is delayed because of the production of vegetative branches. Even when the plants begin to flower early in the season they may not produce an early crop, for the first of the fruiting branches are borne at the base of the main stalk, where they may be surrounded and overshadowed by the vegetative branches, so that the early buds are often blasted or the bolls fail to reach normal maturity.

The need of restricting the growth of the plants in the early stages of development has been recognized in Louisiana in the practice of deep cultivation, which has the effect of root pruning and is used as a means of inducing earlier fruiting. But a still more effective means of controlling the behavior of the plants has been found. The development of vegetative branches can be avoided by leaving the plants closer together during the early stages of growth; that is, by allowing the plants to grow larger before they are thinned and then leaving them closer together in the rows than has been customary.[1]

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[1] Cook, O. F. Local adjustment of cotton varieties. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 159, 75 p., 1909.

——— Cotton selection on the farm by the characters of the stalks, leaves, and bolls. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 66, 23 p., 1910.

——— Cotton improvement under weevil conditions. U. S. Department of Agriculture, Farmers' Bulletin 501, 22 p., 1912.

To bring the plants to early fruiting by controlling the formation of branches seems to have distinct advantages over root pruning by deep cultivation, for controlling the branches does not involve any sudden checking of the growth of the plants, by which time may be lost in the development of the crop. There is also the danger that severe root pruning, if carried into the fruiting period, may cause the shedding of the flower buds and thus delay the crop in another way. The effect of the two systems is the same in the general sense that the individual plants do not grow as large as when no restrictions are imposed, but with the new system this limitation of the size of the individual plant is made good by leaving larger numbers of plants in the rows, though at the same time avoiding the injurious effects that would come from crowding if the vegetative branches were not suppressed. Nevertheless, the two methods of restricting growth can be readily combined if this should prove necessary under the extreme conditions found in Louisiana.

Another feature of the new system that may be of special value in Louisiana is that it may carry with it the possibility of securing an additional advantage from topping the plants as a further means of hastening the development of the crop. Under the usual system that allows the plants to develop vegetative branches topping often fails completely of its desired effect, or may even be injurious, since cutting off the main stalk may only stimulate the development of the vegetative branches. But with the vegetative branches suppressed the topping of the main stalk toward the end of the season may become a useful measure. These are some of the questions that require further experimental study.

It is still too early for any expression of opinion regarding the advantage to be gained from the new system under Louisiana conditions, but the results that have been secured in California and Texas seem to leave no doubt of the possibility of suppressing the vegetative branches and thus changing the habits of growth in the direction of earlier fruiting. With the vegetative branches out of the way the fruiting branches have better exposure to the sun and attain a better development. The plants are more upright, and the space between the rows is not filled by projecting vegetative branches.

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[1] Cook, O. F. A new system of cotton culture. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 115, p. 15–22, 1913.

——— Abortion of fruiting branches in cotton. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 118, p. 11–16, 1913.

This facilitates late cultivation and increases the chances of drying out the fallen buds, or "squares," and thus killing the weevil larvæ that the squares contain.

RELATION OF LOUISIANA CONDITIONS TO BOLL-WEEVIL INJURY.

Conditions that induce excessive growth and late fruiting of the cotton represent a maximum of exposure to weevil injury. The early flower buds enable the weevils to begin breeding, and the large bushy plants protect the larvæ in the fallen squares from the heat and dryness that might otherwise destroy many of them. By the time that the large plants have reached the stage of heavy fruiting the weevils are likely to have become so numerous that all of the buds are destroyed and no more bolls can be set.

That the boll weevil would be likely to drive the old late-maturing varieties of long-staple cotton out of cultivation was foreseen before Louisiana was invaded, and it was on this account that the development of earlier long-staple varieties was undertaken by the Department of Agriculture about a decade ago. This interval of time has proved sufficient for the development of improved types of long-staple cotton and improved methods of long-staple production.

Another reason why the weevil danger appears more serious in Louisiana is because much of the country is wooded and thus affords unusual facilities for the hibernation of the insects, especially in timber overhung with Spanish moss. The prolonged periods of drought that often decimate and sometimes almost exterminate the weevil population over wide regions in Texas are less likely to give respites from weevil danger in Louisiana.[1]

The conclusion to be drawn from these facts is not that cotton culture has become impossible in Louisiana, for good crops are often raised in the presence of the boll weevil, but that all the precautions for avoiding weevil injury will need to be observed even more carefully and efficiently in Louisiana than in other parts of the cotton belt.

MEASURES OF PROTECTION AGAINST THE BOLL WEEVIL.

Many ways of avoiding boll-weevil injury have been suggested, but to secure a maximum of protection several different measures need to be combined. Communities should unite upon the same variety of cotton, plant it at the same time in the spring, use improved cultural methods to shorten the crop season, and clear the fields early in order to deprive the weevils of food and breeding places in the late fall and early spring months.

In communities that could agree to begin the planting of their cotton on the same date very early planting would not be necessary, and this would be an advantage for the community as a whole, for the weevils would have less opportunity to breed than if some of the cotton were planted very early; and, on the other hand, there would be less danger of injury to the crop from periods of cold or wet weather or from spring floods. Where spring floods are of frequent occurrence and likely to interfere with early planting it is especially important to learn the extent to which weevil injury may be avoided by other means, such as the control of the habits of branching.

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[1] Cook, O. F. Relation of drought to weevil resistance in cotton. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 220, 30 p., 1911.

If the necessary precautions were observed, the power of the weevil to inflict serious injury or destroy the crop would be limited to the unfavorable seasons that might not permit the cotton to set a full crop of bolls before the weevils could become destructively numerous. That further advantages may be gained, at least in particular cases, by picking up the fallen squares or by the poisoning of overwintered weevils on the young plants in the spring is not improbable, but it is certainly a mistake to suppose that these measures can be relied upon and the others neglected.[1]

One of the chief obstacles in the way of a proper appreciation and application of methods of weevil control is likely to come from the fact that there will be occasional good seasons, with enough dry weather in the early part of the growing season to hold the weevils in check, even in districts where no precautions have been taken. Fortunately, or perhaps unfortunately, seasons of this kind have already occurred since the weevils reached Louisiana, and some of the planters have been encouraged to believe that they could go ahead with cotton raising on the same basis as before the weevils arrived. Thus, from the standpoint of permanent improvement of the industry, favorable seasons may be more dangerous than those that show the advantage of adopting improved methods.

Many people find consolation in the idea that the weevil will pass on in a few years or that some new enemy or other restrictive agency will intervene to mitigate its ravages. But such reflections should not be advanced as reasons for neglecting to adopt better varieties and methods of production, for these improvements are of value quite apart from the problem of weevil resistance, as shown by experiments in California and Virginia, where no weevils exist. The difference is that in the presence of the boll weevil greater intelligence and skill become necessary to grow cotton successfully and that larger numbers of farmers must adopt the improved methods if production is to be maintained.

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[1] Hunter, W. D. The boll weevil problem, with special reference to means of reducing damage. U. S. Department of Agriculture, Farmers' Bulletin 512, 46 p., 9 fig., 1912.

THE DEMAND FOR LONG-STAPLE COTTON.

The commercial factor is perhaps the most uncertain. The future of the long-staple industry in Louisiana, as well as in other parts of the United States, depends upon the extent to which this kind of fiber is used. To solve the agricultural problems of producing long-staple cotton may avail little if the manufacturing problems are to be solved on the basis of short staples. The tendency of the manufacturing world for many years past has been toward a substitution of short staples for long. The textile machinery has been improved, instead of improving the cotton.

Until a few decades ago all of the finer fabrics required long-staple cotton, but the successive steps of mechanical improvement have made it possible to spin finer and finer threads of short cotton and produce fabrics closely similar to those that had been made previously from long staples. Whatever the advantages of economy to the manufacturer, the substitution of short fiber for long is not in the interest of the consuming public. The short-staple fabrics are undoubtedly inferior in strength and durability. Indeed, this lack of durability is appreciated by manufacturers as tending to more frequent sales and larger profits. As long as it is more profitable to supply the short-staple fabrics they will doubtless continue to be furnished.

The substitution has gone on very gradually, of course, and without attracting any attention from the general public. Indeed, the public is now without any means of distinguishing long-staple fabrics from short, for the quality can no longer be judged, as formerly, by the fineness of the fabric. What may be considered as the last campaign of substitution dates back a few years, when a small cotton crop in Egypt aroused the apprehension of the manufacturers regarding the supply of that type of long-staple cotton. The result was that new lines of substitutes for Egyptian cotton fabrics, made of American Upland cotton, were placed on the market. Thus, the gradual substitution of shorter staples has gone on until now the manufacturers of thread consider theirs as the only branch of the textile industry that is really dependent on long-staple cotton. Thread, of course, must be strong, because its strength is so easily tested, but for most other purposes the substitution of short fiber is possible, if not already accomplished.

Even in articles like automobile tires that are popularly supposed to be made of Sea Island cotton, short fiber is being used. The Sea Island industry, instead of being stimulated by the manufacture of automobile tires, has stood still or declined, so that the planters of this cotton in South Carolina, Georgia, and Florida have had difficulty in selling their recent crops.[1]

If the tendency to substitution can be resisted by educating the public regarding the superior strength and durability of long-staple cotton the prospects of long-staple production in Louisiana and elsewhere will be greatly improved. The general use of inferior fiber in all of our ordinary clothing and household fabrics represents in the aggregate an enormous tax upon the consuming public. Indeed, it would be difficult to mention any other element of industrial waste that affects so many people and in so many ways as the use of inferior cotton fiber. That means of protection will be found eventually can hardly be doubted, but it is impossible to tell in advance how long it will take or to give any assurances regarding the immediate future of the long-staple industry. Although good prices have been realized in the last few years, the recent tendencies of the market have been distinctly downward, for no apparent reason unless it be that the success of further steps in the direction of substitution of short staples has resulted in a further reduction of the demand. A slight increase of production of long staples has occurred in the Carolinas, but hardly more than enough to supply the neighboring mills.

THE RELATION OF COTTON TO OTHER TROPICAL CROPS.

Cotton having become less reliable as a single crop on account of the boll weevil, there is greater need of combining it with other crops, in order to make the agricultural system stable as a whole. Hence, the possibility of introducing other profitable crops should receive attention. It would be a mistake to consider cotton alone if any special investigations or experiments are to be undertaken in the interest of the Louisiana cotton industry. A full development of the agricultural resources of Louisiana is likely to require the adoption of special crops as well as special methods of farming. In view of her fertility of soil, abundant moisture, and long growing seasons Louisiana must be considered as one of the richest, potentially, of the agricultural areas of the United States. The summer climate of Louisiana is really tropical and some of the tropical crops may be found useful.

While many tropical crops have been planted experimentally in Louisiana it can not be said that there has been any adequate canvass of the possibilities that lie in this direction. The behavior of a tropical plant when placed for the first time under new conditions may be altogether abnormal, as in the case of some of the new types of cotton introduced in recent years from tropical America. But by acclimatization and selection it has been possible in a few years to obtain early productive varieties from stocks that grew into large sterile bushes when first introduced.[1]

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[1] The possibility of establishing Sea Island cotton in Louisiana is often suggested, but the danger of weevil injury would probably be greater, and the Sea Island cotton does not seem likely to become a profitable crop on account of low yield, late maturity, and small size of bolls that increases the difficulty of picking. Some of these objections would also attach to the Egyptian cotton in Louisiana, though perhaps to a less extent. If grown at all, these cottons would have to be taken up by separate communities where no Upland cotton was planted. Another consideration with the Sea Island cotton is that active competition is being developed in some of the West Indies, where there are no boll weevils.

The luxuriant growth of weeds lends another tropical aspect to agriculture in Louisiana. The weeds not only take full advantage of the opportunities of perennial growth, but are ready to spring up at any time that the land is left idle. One crop needs to follow another in quick succession in order to keep control of the weeds and at the same time keep down the expenses of cultivation. To insure the prompt succession of crops it is often necessary to plant two together or to sow one before the other is taken off. Thus, there may be another important advantage in shortening the growing season of cotton so that it can be raised in rotation with winter crops.

Other possibilities lie in the use of tree crops to assist in weed control or to give favorable conditions for other crops that thrive better with partial protection from the sun. We are accustomed to think of agriculture as an art that must be practiced out in the sun in the open field, but in tropical and subtropical countries many crops are grown as subcultures under the protection of trees. Thus, in some districts of southern Italy much of the agriculture is of this intensive character. Labor may be reduced by such methods, but intensive care and skill are required to combine crops successfully. Even cattle raising, which seems to have excellent prospects in Louisiana, must be done on a more intensive basis, as in the Tropics, for rich lands are soon covered with woody growth unless measures are taken to protect the grass or to maintain a rotation with other crops. Some of the tropical grasses might prove valuable in relation to the problem of weed control as well as for pasture or fodder.

In some important respects Louisiana must be considered as the most tropical part of the United States, as shown by the conjunction of three distinctively tropical crops—sugar, cotton, and rice. It is true that Florida and Texas extend farther south, but they do not afford to the same extent the tropical combination of rich alluvial soil and abundant moisture. The lands along the lower Mississippi also afford unusually favorable opportunities for developing methods of frost protection, especially with crops that could be saved by flooding from the river. Tree crops or perennials that will not survice frost are excluded, of course, but many annual crops are grown in different parts of the tropical and subtropical world, and some of these should prove adapted to the summer tropical conditions found in Louisiana. Southern China is a region with a variable continental climate, not unlike that of Louisiana, where many of the more hardy types of tropical plants have been cultivated for long periods of time and contribute to the support of enormous agricultural populations.

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[1] Cook, O. F. Heredity and cotton breeding. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 256, 113 p., 19 fig., 6 pl., 1913.

Even among the tropical plants already established in the United States there are some that are capable of much more extensive utilization than at present. The chayote and the dasheen may serve as illustrations of tropical crops now available for use in Louisiana. The chayote, or " mirliton," as it is usually called in the New Orleans markets, is a member of the squash family, producing a large climbing vine and an edible fruit with excellent possibilities of finding a place in northern markets. The reason why the chayote has not attracted more attention in Louisiana may be that the variety now grown about New Orleans is of only indifferent quality in comparison with others that are known to exist in Central America. Throughout the table-lands of Central America the chayote is the favorite garden vegetable and is grown in larger quantities than any other.[1]

The dasheen is a superior variety of the taro, a plant used very extensively on the Pacific islands and other tropical countries. It is a starchy root crop, corresponding roughly to the potato, and in some respects actually superior. It grows in moist, rich land, and there are varieties that thrive even in swamps. The chief problem here, as with the chayote, is one of utilization, that is, of an effective introduction of the plant to the consuming public.[2]

The possibility of developing a stable and profitable system of agriculture in Louisiana is of more than local interest, on account of its relation to the national problem of control of the Mississippi River. The value of land for agricultural purposes is a very important factor in determining the feasibility of developing an effective system of river control. The introduction and establishment of more profitable crops might change the situation completely. Lands used for the production of cotton in the valley of the Nile are valued as high as $1,000 an acre. Any approach to such values for agricultural lands in the Mississippi Valley would place the problems of river control and reclamation on an entirely different footing. But time is required for the realization of any such possibilities. Any new crop must pass through an experimental period. The habits of the plant and its reactions to the local conditions must be learned, cultural methods must be devised, and superior varieties must be bred or acclimatized before the public can be expected to adopt the new crop, or even to appreciate its possibilities.

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[1] Cook, O. F. The chayote: A tropical vegetable. U. S. Department of Agriculture, Division of Botany, Bulletin 28, 31 p., 8 pl., 1901.

[2] Young, R. A. The dasheen, a root crop for the Southern States. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 127, p. 25-36, 3 fig., 1913.

CONCLUSIONS.

The measures of improvement suggested in the preceding pages may be summarized as follows:

(1) *The investigation of new long-staple varieties of cotton and improved cultural methods*, or, if necessary, the development of new varieties and methods specially adapted to Louisiana conditions.

Early long-staple varieties and cultural methods that induce earlier fruiting have been developed recently by the Department of Agriculture, following a series of experiments in the drier parts of Texas and in irrigated districts of Arizona and California. But both the varieties and the methods are new and their value for Louisiana is still unknown. The possibilities of maintaining the long-staple industry in Louisiana or of utilizing the sugar lands for long-staple cotton must be determined by experiments under the local conditions.

(2) *The organization of cotton-growing communities* in order to secure more adequate protection against the boll weevil, produce uniform staples, and market the crop to better advantage.

The presence of the boll weevil introduces another variable factor into the cotton problem. Cotton being no longer a "sure" crop, the agricultural basis of the credit system of farming is impaired and the resulting disturbance of economic conditions is much more serious than could have occurred with any crop less confidently relied upon. This explains why social and economic considerations enter so largely, especially in a State like Louisiana, where the danger of weevil injury is greatest.

(3) *The education of the consumer* regarding the value of long-staple cotton as a means of securing strength and durability in clothing and other textile products.

Though no adequate development of the long-staple cotton industry is to be expected while the substitution of inferior cotton continues, this substitution is so wasteful industrially and so costly for the consuming public that it can hardly be allowed to continue indefinitely.

(4) *The acclimatization of other tropical crops*, so that cotton culture in Louisiana may become a branch of a safer and more diversified system of agriculture.

Tropical crops are especially indicated as a means of taking advantage of the local conditions of climate and soil that exist in Louisiana and also to avoid the competition of other States which have more favorable conditions for temperate crops. The agricultural resources of Louisiana will not be fully known until the possibilities of acclimatizing other tropical crops have been thoroughly tested.

THE USE OF CONGO RED IN CULTURE MEDIA.[1]

By **Karl F. Kellerman**, *Physiologist in Charge of Soil-Bacteriology and Plant-Nutrition Investigations.*

INTRODUCTION.

In an earlier publication[2] mention was made of the value of a medium colored with congo red as a presumptive identification of the organism *Bacillus tumefaciens*, which is the cause of crown-gall of orchard trees, vines, etc., and which also produces tumors upon the roots of tomatoes, sugar beets, carrots, clover, alfalfa, and other plants. Certain strains of *Bacillus tumefaciens* if grown upon a suitable nutrient agar distinctly colored with congo red absorb the dye, thus staining the bacterial growth a vivid red and at the same time bleaching the layer of the culture medium. The absorption of the congo-red dye from the medium by the growing colony is usually such a decisive and striking action with many strains of *Bacillus tumefaciens* that it seemed desirable to test the diagnostic value of congo-red media for the common saprophytic bacteria.

DESCRIPTION OF TESTS OF CULTURES.

Through the courtesy of Prof. C.-E. A. Winslow 28 species of bacteria were secured from the American Museum of Natural History, and these, together with two strains of *Bacillus tumefaciens*, were plated out in Petri dishes in quadruplicate and were also grown in stab culture in various media. The fact that there had been recently isolated new species of bacteria[3] which destroy cellulose and which are also able to grow luxuriantly upon the usual standard culture media, such as beef agar, beef gelatin, and milk, has suggested the possibility that many of the common saprophytic bacteria described by various authors might have the power of dissolving cellulose. Although the determination of a cellulose-dissolving function has no connection whatever with the diagnostic value of congo-red media, for mechanical reasons it has been convenient to study simultaneously the action of various species of bacteria upon cellulose media as well as upon congo-red media.

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[1] Issued June 21, 1913.

[2] Kellerman, Karl F. The relation of crown-gall to legume inoculation. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 76, 6 p., 1 pl., 1911.

[3] Kellerman, Karl F., and McBeth, I. G. The fermentation of cellulose. Centralblatt für Bakteriologie [etc.], Abt. 2, Bd. 34, No. 18/22, pp. 485–494, 2 pl., 1912.

McBeth, I. G., and Scales, F. M. The destruction of cellulose by bacteria and filamentous fungi. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 266, 50 p., 4 pl., 1913.

Four kinds of media were used:

Agar A.—The synthetic nitrogen-poor agar designed for the isolation of strains of *Bacillus tumefaciens*, prepared as follows: Water, 1,000 cubic centimeters; sugar, 10 grams; potassium phosphate (monobasic), 1 gram; magnesium sulphate, 0.2 gram; agar, 15 grams; and congo red, 0.1 gram.

Agar B.—Beef agar made in accordance with the recommendations of the committee upon standard methods of the American Public Health Association, with the addition of 0.01 gram of congo red to each liter.

Agar C.—A synthetic agar designed for the isolation of cellulose ferments of the following composition: Precipitated cellulose, 5 grams; agar, 10 grams; potassium phosphate (dibasic), 0.5 gram; magnesium sulphate, 0.5 gram; sodium chlorid, 0.5 gram; ammonium sulphate, 1 gram; calcium carbonate, 1 gram; tap water, 1,000 grams.

Agar D.—A synthetic agar similar to that described under agar C, except that peptone was substituted for ammonium sulphate.

Table I shows the action of the various cultures upon these culture media. In no case did subcultures react differently from the original culture. It should be remembered, however, that the writer has previously noted that strains of *Bacillus tumefaciens* isolated from different host plants show wide differences of absorptive power toward congo red and that the cause of this variation is as yet unexplained.

TABLE I.—*Action of various species of bacteria upon congo-red media and upon cellulose media.*

Species.	Congo-red media.		Cellulose media.		Species.	Congo-red media.		Cellulose media.	
	Agar A.	Agar B.	Agar C.	Agar D.		Agar A.	Agar B.	Agar C.	Agar D.
Azotobacter chroococcum	+	−	−	−	Bacillus balticus	−	−	−	−
A. vinelandii	−	−	−	−	B. amylovorus	−	−	−	−
A. beijerinckii	−	−	−	−	B. capsulatus	−	−	−	−
Diplococcus gadidarum	−	−	−	−	B. fluorescens (liquefaciens)	+	+	−	−
Bacillus tumefaciens	++	+	−	−	B. lactis	−	++	−	−
B. acidi-lactici	−	−	−	−	B. fluorescens	+	+	−	−
B. kiliensis	−	−	−	−	Actinomyces asteroides	+	++	−	−
B. alcaligenes	−	−	−	−	Bacillus prodigiosus	+	++	−	−
B. communior "A 1"	−	−	−	−	B. acidophilus	−	−	−	−
B. aquatilis	+	+	−	−	Cladothrix dichotoma	+	+	−	−
Mycobacterium tuberculosis	−	−	−	−	Bacillus astheniae	−	−	−	−
Micrococcus flavus	−	−	−	−	B. aurantiacus	+	+	−	−
Bacillus proteus	−	−	−	−	B. butyricus	+	++	−	−
B. niger (liquefaciens)	−	−	−	−	B. lactimorbi	+	+	−	−
B. carotovorus	−	+	−	−	B. communior (rubra)	−	−	−	−
B. stewartii	−	−	−	−	B. rutilescens	+	+	−	−
B. melonis	−	+	−	−	B. campestris	−	−	−	−
B. danysz	−	−	−	−	B. juglandis	+	+	−	−
B. plicatus	−	+	−	−	B. candicans	−	−	−	−
B. phosphorescens	−	−	−	−	B. fluorescens (tenuis)	−	−	−	−
B. gasoformans	−	−	−	−	B. saccharolyte	−	−	−	−
B. communior (lutea)	+	−	−	−	B. cyaneus	+	−	−	−
Micrococcus citreus	−	−	−	−	B. arborescens	−	+	−	−
Bacillus aerogenes	−	−	−	−	Denitrifier	−	+	−	−

CONCLUSIONS.

It is interesting to observe that none of the organisms tested up to the present time show as strong an absorption of dye from the synthetic nitrogen-poor medium as do certain strains of *Bacillus tumefaciens*, while upon beef agar four other species exhibit the greatest activity. Practically all stab and streak cultures show more or less absorption along the edge of the broken agar surface, but this seems to be due to the staining of slime where the bacterial growth is oldest and to the staining of dead bacteria killed in transferring. The living bacteria themselves, however, of at least certain strains of such species as *Bacillus tumefaciens*, *B. butyricus*, *B. prodigiosus*, *B. lactis*, etc., can absorb congo red, which, like the relation of bacterial strains to gentian violet described by Churchman and Howard,[1] would seem to indicate that this phenomenon is associated with some protoplasmic function. Observations upon bacterial cells of *Azotobacter chroococcum* impregnated with congo red show that upon cell division at least frequently one red and one colorless cell are formed.

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[1] Churchman, John W., and Howard, Michael W. The selective action of gentian violet on closely related bacterial strains. Journal of Experimental Medicine, v. 16, no. 6, pp. 822–830, 1912.

[Cir. 130—C]

A SIMPLE AND ECONOMICAL METHOD OF BURNING LIME.[1]

By J. H. **Arnold**, *Agriculturist*, and **John E. Nichols**, *Agent, Office of Farm Management.*

INTRODUCTION.

This paper represents the results of the experience in burning lime on the farm of Benjamin Cherry, in Warren County, Ky., where two kilns were burned during the preceding winter and the spring of 1913. The details of the operation are given so that any farmer in Kentucky, West Virginia, or Tennessee who has good limestone on his land may burn lime in a similar manner.

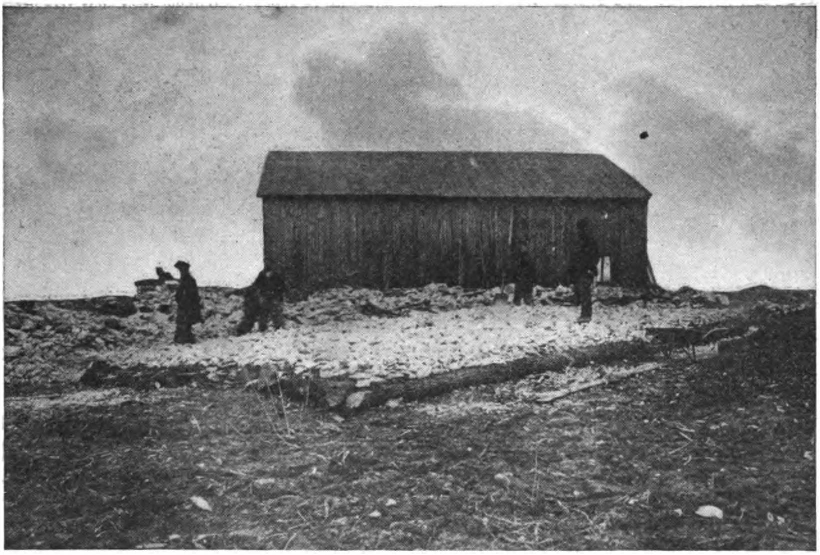

FIG. 1.—Wood bottom of kiln and first layer of limestone.

CONSTRUCTION OF THE KILN.

The kiln was located on top of a bed of limestone, the greater part of which was exposed or very near the surface. Poles and slabs were placed lengthwise on the ground, making a layer 30 feet long and 16 feet wide, as shown in figure 1. The largest poles, 8 or 10 inches in diameter, were used for the outside rows in order to make a more stable foundation. The smaller poles and slabs were placed between the large outside poles; and these made up the layer, except for a strip 2 feet wide in the middle, where small wood and kindling were placed the entire length of the kiln. Chinks between the poles and slabs were filled with fine wood and cornstalks.

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[1] Issued June 21, 1913.

Fine coal was then placed as a second layer to a depth of 2 inches. On top of the coal was placed a 4 or 5 inch layer of limestone, crushed to the size of a man's head or smaller. (Fig. 2.) Another layer of coal was then added and this was followed by a layer of limestone 12 to 14 inches thick. Alternate layers of coal and stone were added to these until the pile was 7 or 8 feet high. The sides were gradually drawn in, making the pile somewhat pyramidal in shape and drawing it to a peak, and were then coaled up by shoveling on as much as the crevices would hold. The kiln was then ready to be fired.

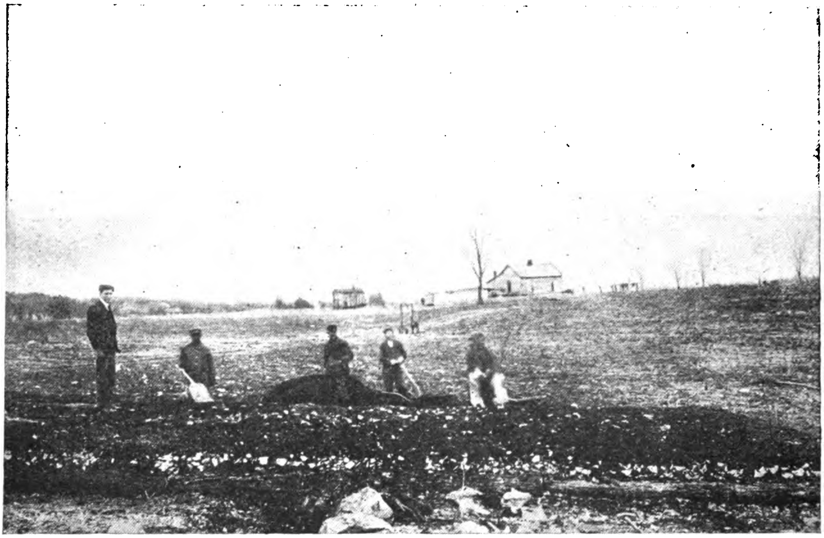

FIG. 2.—The kiln in the third step of building. A layer of coal is being added to cover the layer of limestone.

METHOD OF BURNING.

A fire was started on the windward end near the middle, where the strip of kindling had been placed. This gradually began to burn. In a day or two, as the fire began to burst out of the sides, dirt was shoveled over it to smother the fire and keep it from burning too rapidly. The burning of the kiln continued about two weeks. After it had cooled off, the dirt was removed in order to allow the rains to sink in and to slake the lime, after which it was ready to be used on the land. (Fig. 3.)

COST OF BURNING.

It is estimated that the kiln referred to contained about 2,400 bushels, or nearly 87 tons, of lime. The expenses were as follows:

Quarrying stone:	
Labor, 1 man for 2 weeks	$12.00
Dynamite	1.00
Coal, 453 bushels, or 16¼ tons, at 8 cents per bushel	36.24
Wood (4 loads)	2.50
Labor in making and tending kiln	18.36
Miscellaneous work and materials	10.00
Total	80.10

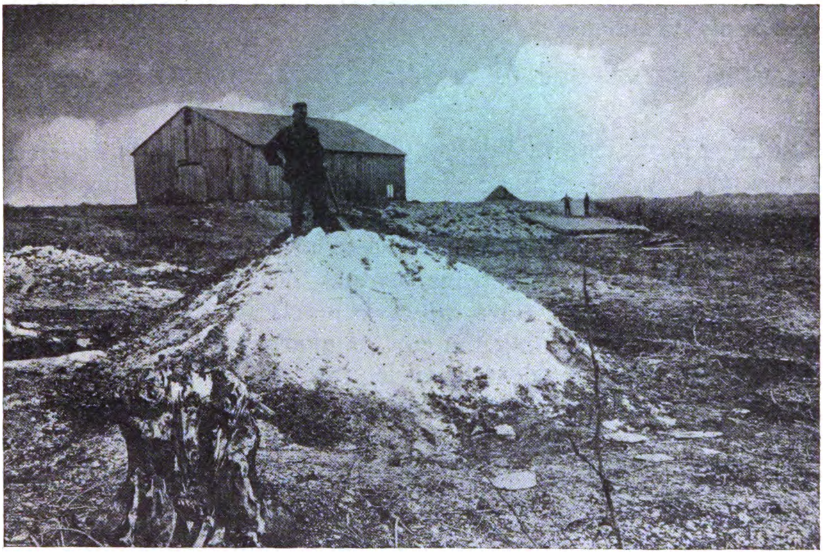

FIG. 3.—A heap of burnt lime ready to apply to the land. The dirt was removed when the burning was finished and the rains have slaked the lime.

On a kiln of the same dimensions built on a neighboring farm the expenses were somewhat higher, as follows:

Coal	$45.00
Wood	6.00
Hauling wood and stone	6.00
Labor in quarrying and in making and tending kiln	36.00
Total	93.00

On each of these farms the labor was all hired, but in many cases this could be supplied entirely by the farmers during the winter, when little else could be done, and at the same time the land could be cleared of stone and cultivated. The coal could have been secured for 6 cents a bushel if bought during the summer.

CAUTION REGARDING THE USE OF LIME.

There is an old English proverb which, in substance, says that the use of lime on land makes the father rich and the son poor. Caustic lime should be used with good judgment, and no more should be applied than the land requires in order to neutralize it. From 800 to 2,000 pounds to the acre is the quantity of caustic lime usually applied, or from 2,500 to 5,000 pounds of ground limestone. Caustic lime should never be scattered on growing plants.

Lime uses up the humus in the soil very fast; hence, this important ingredient of the soil must be constantly and liberally supplied by plowing under vegetable matter in the form of green cover crops or stable manure.

RELATIVE EFFICIENCY OF AGRICULTURAL LIME AND GROUND LIMESTONE.

On three farms, two in Warren County, Ky., and one in Jefferson County, W. Va., the average cost of burning lime according to the methods just described was about $1 per ton of finished product, burnt or stone lime. On one of these farms the average cost of grinding the limestone to such fineness that the largest particles would pass through a 10-mesh sieve, which is practically fine enough, was about $1 per ton, including the cost of quarrying. Of good burnt lime 56 pounds is equivalent in agricultural value to 100 pounds of finely crushed limestone or to 74 pounds of "hydrated" lime. The product known as "agricultural lime," "ground lime," etc., is usually partly hydrated and partly carbonated, and hence is a little less valuable than pure hydrated lime.

REFERENCES AND SOURCES OF SCIENTIFIC INFORMATION.

Most of the experiment stations in the eastern section of the United States have carried on experiments in liming the land. The following bulletins will be of interest to farmers in the three States to which this circular applies:

ELLET, W. B.
Lime for Virginia farms. Virginia Agricultural Experiment Station, Bulletin 187, 48 p., 23 fig., 1910.

HITE, B. H., and KUNST, F. D.
Commercial fertilizers. Complete report for 1909. West Virginia Agricultural Experiment Station, Bulletin 125, 102 p., 1910.

PATTEN, A. J., and JEFFREY, J. A.
Lime for agricultural purposes. Michigan Agricultural Experiment Station, Circular 11, p. 79–82, 1911.

Mooers, C. A.

Fertility experiments in a rotation of cowpeas and wheat. Pt. 1. The utilization of various phosphates. Tennessee Agricultural Experiment Station, Bulletin 90, p. 57–90, 1910.

Wheeler, H. J.

The liming of soils. U. S. Department of Agriculture, Farmers' Bulletin 77, ed. 2, rev., 19 p., 1899.

Grinsley, G. P.

The limestone and lime industry of West Virginia. West Virginia Geological Survey [Report], v. 3, chap. 17–22, p. 312–422, 6 fig., 11 pl. [1906].

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